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starboard tack, should have brought us to a point with Wicklow Head, lying W. by N., twenty-one miles distant."

It is clear from this that the captain made an allowance for the point of error he had discovered. Had he applied it in the opposite direction, he would undoubtedly have mentioned that he did so and why he did so.

The particular conclusions, then, which I draw from the facts of the case are these:—

1. There must have been a large heeling error affecting the steering-compass of the 'Glenorchy,' which, on the courses steered, would be a westerly deviation on the *starboard tack*, an easterly deviation on the *port tack*.

2. The westerly deviation detected on the *starboard tack* was this heeling error.

3. The true construction to be put on the captain's statement is, that when on the *port tack* he allowed for the point of deviation which he had detected on the *starboard tack* as a point of westerly deviation, not as a point of easterly deviation, as he would have done had he known the cause and the law of the deviation which he had detected.

4. That, in consequence, his supposed course was in error one point *plus* the heeling deviation, which, on a S.W. by W. course, was probably about one point more.

The general conclusions to be drawn from the history of the shipwreck seem to me to be:—

1. The great importance of selecting a position for the navigating-compass where the force of the ship's magnetism is moderate and uniform.

2. The importance of extending the usual process of "adjustment" of a compass to the ascertaining and (if necessary) the correcting of the heeling error. This is a matter of no difficulty if the compass-adjuster is duly instructed and supplied with the requisite instruments.

III. "Spectroscopic Observations of the Sun.—No. IV." By J. NORMAN LOCKYER, F.R.A.S. Communicated by Dr. SHARPEY, Sec.R.S. Received April 14, 1869.

I beg to lay before the Royal Society very briefly the results of observations made on the 11th instant in the neighbourhood of a fine spot, situated not very far from the sun's limb.

- I. Under certain conditions the C and F lines may be observed *bright on the sun*, and in the spot-spectrum also, as in prominences or in the chromosphere.

- II. Under certain conditions, although they are not observed as bright lines, the corresponding Fraunhofer lines are blotted out.

- III. The accompanying changes of refrangibility of the lines in question

show that the absorbing material moves upwards and downwards as regards the radiating material, and that these motions may be determined with considerable accuracy.

IV. The bright lines observable in the ordinary spectrum are sometimes interrupted by the spot-spectrum, *i. e.* they are only visible in those parts of the solar spectrum near, and away from, spots.

V. The C and F lines vary excessively in thickness over and near a spot, and on the 11th in the deeper portion of the spot they were much thicker than usual.

IV. Stars, in the spectrum of which the absorption-lines of hydrogen are absent, may either have their chromospheric light radiated from beyond the limb just balanced by the light absorbed by the chromosphere on the disk, or they may come under the condition referred to in (II.), either absolutely or on the average.

ADDENDUM.—Received April 29, 1869.

Since the date on which the foregoing paper was written, I have obtained additional evidence on the points referred to. I beg therefore to be permitted to make the following additions to it.

The possibility of our being able to determine the velocity of movements of uprush and downrush taking place in the chromosphere depends upon the alterations of wave-length observed.

It is clear therefore that a mere uprush or downrush at the sun's limb will not affect the wave-length, but that if we have at the limb cyclones, or backward or forward movements, the wave-length will be altered; so that we may have:—

1. An alteration of wave-length near the centre of the disk caused by upward or downward movements.
2. An alteration of wave-length close to the limb, caused by backward or forward movements.

If the hydrogen-lines were invariably observed to broaden out on both sides, the idea of movement would require to be received with great caution; we might be in presence of phenomena due to greater pressure, both when the lines observed are bright or black upon the sun; but when they widen out sometimes on one side, sometimes on the other, and sometimes on both, this explanation appears to be untenable, as Dr. Frankland and myself in our researches at the College of Chemistry have never failed to observe a widening out on both sides the F line when the pressure of the gas has been increased.

On the 21st I was enabled to extend my former observations.

On that day the spot, observations of which form the subject of the paper, was very near the limb; as this was the first opportunity of

observing a fine spot under such circumstances I had been able to utilize, I at once commenced work upon it. The spot was so near the limb that its spectrum and that of the chromosphere were both visible in the field of view.

The spot-spectrum was very narrow, as the spot itself was so greatly foreshortened; but the spectrum of the chromosphere showed me that the whole adjacent limb was covered with prominences of various heights all blended together.

Further, the prominences seemed fed, so to speak, from, apparently, the preceding edge of the spot; for both C, F, and the line near D, *were magnificently bright on the sun itself*, the latter especially striking me with its thickness and brilliancy.

In the prominences C and F were observed to be strangely gnarled, knotty, and irregular, and I thought at once that some "injection" must be taking place. I was not mistaken. On turning to the magnesium lines I saw them far above the spectrum of the limb and unconnected with it.

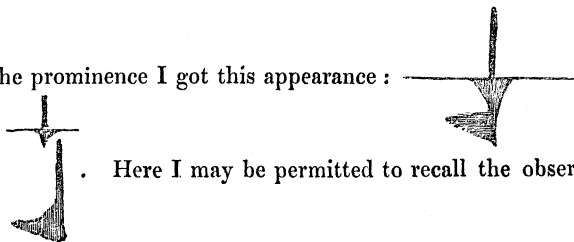
A portion of the upper layer of the photosphere had in fact been lifted up beyond the usual limits of the chromosphere, and was there floating cloud-like.

The vapour of sodium was also present in the chromosphere, though not so high as the magnesium, or unconnected with the spectrum of the limb, and, as I expected, with such a tremendous uplifting force, I saw the iron lines (for the first time) in the spectrum of the chromosphere.

My observations commenced at 7.30 A.M.; by 8.30 there was comparative quiet.

At 9.30 the action had commenced afresh; there was now a single prominence.

At the base of the prominence I got this appearance :



Higher up this :



Here I may be permitted to recall the observation made on March 14, in which a slight movement of the slit gave

me first  , then  , and finally  , all these

appearances being due to cyclonic action.

On the following side of the spot, at about 10 A.M., I observed that the F line had disappeared; at the point of disappearance there appeared to be an elongated brilliantly illuminated lozenge lying across it at right angles, as if the spectroscope were analyzing the light proceeding from a cyclone of hydrogen on the sun itself, but so near the limb that the rotatory motion could be detected.

The next observations I have to lay before the Royal Society were made on the 27th inst. Careful observations on the 25th and 26th revealed nothing remarkable except that the chromosphere was unusually uniform.

On the 27th a fine spot with a long train of smaller ones and faculæ was well on the disk. The photosphere in advance of the spot, and the large spot itself, showed no alteration from the usual appearance of the hydrogen-lines; but in the tails of the spot the case was widely different.

The F line, at which I worked generally, as the changes of wave-length are better seen, was as irregular as on the former occasions.

I. It often stopped short of one of the small spots, swelling out prior to disappearance.

II. It was invisible in a facula between two small spots.

III. *It was changed into a bright line, and widened out on both sides two or three times* IN THE VERY SMALL SPOTS.

IV. Once I observed it to become bright *near* a spot, and to expand over it on both sides.

V. Very many times near a spot it widened out, sometimes considerably, on the less refrangible side.

VI. Once it extended as a bright line without any thickening over a small spot.

VII. Once it put on this appearance :



bright.

VIII. I observed in it all gradations of darkness.

IX. When the bright and dark lines were alongside, the latter was always the less refrangible.

The Society then adjourned over Ascension Day to Thursday, May 13.